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ABSTRACT

Studies of the interactions within the Carroll model of learning, in which degree of learning is considered a function of the ratio of time spent to time needed, are described and evaluated. Evidence in previous research, which focused on the interaction of quality of instruction and ability to understand instruction on degree of learning, time needed, and perseverance, is regarded as inconclusive. It is recommended that researchers consider: (1) the measurement of variables in the model; (2) the interactions of variables in the model; (3) the nature of the function in the model and the best way to describe it; and (4) sub-models for each of the variables in the model. (KM)

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STUDIES OF INTERACTIONS OF FACTORS IN A MODEL OF SCHOOL LEARNING*

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For those of us who are at least somewhat familiar with the research on mastery learning, it should be evident that John B. Carroll's (1963) model of school learning has provided the conceptual basis for much of this work. Building upon the Carroll model, Bloom (1968) and his associates successfully developed mastery learning strategies that are being increasingly utilized by educators at a variety of levels. In some of the areas in which the mastery learning concept (or at least its associated jargon) has become popular, the Carroll model is usually accepted as an act of faith or altogether forgotten. While attending one of the recent AACTE regional conferences on performance-based teacher education, I was pleased to learn that so many colleges of education were exploring the application of the mastery learning concept to their teacher training programs. Yet I was also dismayed

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to find not a single participant who was able to explain where these ideas on mastery learning had originated although I did speak with one dean who felt certain that "learning for mastery" had something to do with "Bloom's Taxonomy." Indeed, I felt somewhat like an anthropologist attempting to discover the long-forgotten meaning of the ritual dance of a primitive tribe.

It has been documented (Block, 1971) that the bulk of research on mastery learning has concentrated on the development of mastery learning strategies in various courses of study. Refining mastery learning strategies to the point where they have general applicability to classroom learning is a worthwhile undertaking. Research of this genre can help put aside the overworked maxim that educational theory never becomes educational practice. However, only a handful of these studies produced evidence concerning the operations of the model on which they were based. Carroll himself has repeatedly stated that his model needs further study (1963, 1971); in fact, his research has suggested the need for possible modifications in the model (Carroll & Spearritt, 1967). What I am calling for is not a moratorium on the development and implementation of mastery learning strategies, but instead, more research on the nature and interrelatedness of the components of the model upon which these mastery learning strategies are based.

Components of the Model

At the risk of putting some of my distinguished colleagues to sleep, I would like to take a few moments to review the basic components of the

Carroll model and demonstrate their hypothesized interrelationships. In its simplest form the model may be stated as:

$$\text{degree of learning} = f\ \frac{\text{time spent}}{\text{time needed}}$$

Time spent is equal to the smallest of opportunity, perseverance, or time needed. Time needed is equal to aptitude, that is, time needed under optimal conditions, plus additional time needed when the quality of instruction is less than optimal. The amount of additional time needed is determined by the interaction of quality of instruction and ability to understand instruction. The direction of this hypothesized interaction is such that the degree of learning for learners low in ability to understand instruction will be more severely retarded than for learners high in that ability when quality of instruction is low. Although not specifically stated in the model, Carroll (1963, 1967) and others (Block, 1971; Gaines, 1971) have suggested that quality of instruction may affect perseverance; that is, as quality of instruction increases, a learner's perseverance will tend to increase. The exact nature of the relationship between quality of instruction and perseverance, however, has not been clearly formulated.

Previous Research Related to the Model

What appears to be one of the earliest attempts to test Carroll's model was carried out by Sjogren and Knox (1965) and later discussed by Sjogren (1967). The basic research question was concerned with the relationship between degree of learning and the ratio of time taken in a learning situation

to time needed by the learner. It was found that the relationship between degree of learning and this ratio was significantly linear, suggesting that the model might be rewritten more economically as:

$$\text{degree of learning} = \frac{\text{time spent}}{\text{time needed}}$$

One of the most perplexing findings in the Sjogren study was that the correlations between the ratio of time spent to time needed and degree of learning were generally lower than the correlations between the ratio and aptitude as measured by the WAIS. In terms of the Carroll model, aptitude cannot be a better predictor of the degree of learning than the ratio of time spent to time needed; in fact, the true ratio should be a perfect predictor of degree of learning. One might suggest that a possible modification of the model is in order. On the other hand, these findings may also be accounted for in terms of the model. Sjogren's estimate of time needed was based on the amount of time taken to complete an instructional program. Such an estimate would be perfectly reliable only in the special case of time spent being equal to time needed. This equality could be verified by checking to see if the degree of learning were equal to 1.00 or total mastery. For example, if a learner spends the same amount of time in completing two instructional programs, there is no assurance that his time needed to master one program is also equal to his time needed to master the other program. If the two programs differ markedly in quality of instruction, then the respective times needed will also differ. The learner may just be exhibiting a consistent level of perseverance. To complicate matters a bit, if we assume

that quality of instruction is related to perseverance in the manner previously described, then equal times spent may mean even larger differences in times needed. Therefore it is entirely possible that the effects of quality of instruction on time spent and time needed could have accounted for these bothersome findings.

My purpose in this analysis is not to discredit an ingenious piece of research but to bring to the attention of researchers in mastery learning the need to consider all the variables in the model.

In order to test the operations of the Carroll model, researchers will have to design experiments in which the direction of the interaction of quality of instruction and ability to understand instruction on degree of learning, time needed, and perseverance can be evaluated. Previous research has generally employed the two-dimensional factorial design with one dimension representing a high to low quality of instructional treatment continuum and the other dimension representing levels of ability to understand instruction also on a high to low continuum.

A study by Kim and others (1969) reported that while the number of pupils reaching mastery in a high quality of instruction treatment was greater than the number reaching mastery in a low quality of instruction treatment, the high quality of instruction treatment proved to be relatively more helpful for below average IQ pupils than for above average IQ pupils. Although pupils' time spent was not reported and no precise statistical test of interaction provided, the data do suggest the direction of interaction

hypothesized in the model.

Carroll and Spearritt (1967), using time taken to reach criterion (time needed) as a dependent variable, found no significant interaction of treatment (high and low quality of instruction) and IQ (ability to understand instruction), contrary to the prediction of the model. They concluded that "high IQchildren were just as much affected by the poor quality of instruction as were the average and low IQ children (p. 10)."

A study by Gaines (1971) attempted to test the interaction of quality of instruction and ability to understand instruction by examining the effects of high and low quality of instruction treatments and seven levels of reading achievement on the degree of learning. No significant interaction was found. The reason for the failure to detect the presence of any interaction in this case may have been attributable to the lack of sufficiently sharp distinctions between the treatments.

With respect to the interaction of quality of instruction and ability to understand instruction on degree of learning and time needed, the evidence in these studies must be regarded as inconclusive.

Although not specifically hypothesized in his model, Carroll (1963) did raise the question of how quality of instruction might affect perseverance. If by raising the quality of instruction we also increase perseverance, this would have the effect of lowering the ratio of time spent to time needed. If quality of instruction does indeed interact with ability to understand instruction on degree of learning and time needed, then quality of instruction

may interact with ability to understand instruction on perseverance in a similar fashion.

The research on this question is indeed meager. Carroll and Spearritt (1967) found a significant interaction between quality of instruction and IQ on the time pupils were willing to spend on a difficult learning task, or simply, perseverance. The direction of this interaction was apparently disordinal and suggested that poor quality of instruction leads to reduced perseverance in the case of high or low IQ pupils, but to increased perseverance in pupils of average IQ. This interaction, as reported, is characteristically different in direction than the hypothesized interaction on degree of learning or time needed.

Possibilities for Future Research

In concluding this presentation I would like to point out what appear to be some pertinent points for researchers to consider in testing Carroll's model.

(1) An obvious starting point in testing the model is the measurement of variables in the model. A number of helpful points have been offered by Carroll (1971), and they will not be repeated here. Future researchers will have to find ways to reduce the measurement errors associated with variables in the model in order to accurately assess effects of interest.

(2) The study of interactions of variables in the model would seem to be the priority research area. Important questions to consider are: Does quality of instruction interact with ability to understand instruction

on degree of learning? On time needed? On perseverance? If so, what are the directions of these interactions?

The analysis of an interaction has long been a troublesome statistical problem for researchers. Recent discussions by Bracht and Glass (1968) and Bracht (1970) have helped somewhat, but the elegant procedures for analyzing a significant interaction outlined by Marascuilo and Levin (1970) have removed nearly all mysticism from this task. The result of their contribution is that we can now describe interactions with increased power and precision.

(3) Once the basic relationships of the variables in the model have been fairly well established, we will be in a much better position to consider degree of learning as some function of time spent to time needed. Some pertinent questions are: What is the nature of this function? Is it best described by a logarithm? A polynomial? Is the function a constant or is it different for different types of tasks?

(4) Eventually, we may begin to construct new sub-models or consider already-existing ones for each of the variables in the model. Just to speculate a bit, we might consider Atkinson's theory of achievement motivation (see Maehr & Sjogren, 1971) in terms of perseverance or some of B. O. Smith's (1963) notions on teaching in terms of quality of instruction.

Carroll's model of school learning has proved to be a strong stimulus for the development of mastery learning strategies in applied settings, yet its appeal to researchers as a model for study can hardly be described

as overpowering. One explanation is that researchers in mastery learning have tended to accept the model and devote their energies to testing the effectiveness of mastery learning strategies rather than the model itself. Another explanation is that it is often easier to gain support for applied as opposed to basic types of research. At any rate, it is unfortunate that a model which is becoming so widely applied in education has not been subjected to more vigorous validation.

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